A PHASE TESTING METHOD FOR RAPIDLY DETERMINING THE STABILITY OF SAUSAGE EMULSIONS

S. A. ACKERMAN, A. J. MILLER and C. E. SWIFT

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ABSTRACT

A phase testing procedure for determining sausage emulsion stability provides a rapid, relatively simple and comparably sensitive alternative to accepted time-consuming cooking or cooking-centrifugation procedures.

INTRODUCTION

MEAT SCIENTISTS have found methods for measuring the stability of meat emulsions to be highly useful in research on emulsion-based products and have developed a number of them (Meyer et al., 1964; Saffle et al., 1967; Townsend et al., 1968). These procedures involve cooking the emulsions to simulate processing temperatures and measuring released fat. Approximately 15–30 min and the use of hot water baths, centrifuges and specialized glassware are required. A relatively rapid method based on electrical resistance has been described by Haq et al. (1973); however, it has not been completely developed.

We became aware of the phase dilution principle for typing emulsions (Hauser and Lynn, 1940) and used it as a basis for developing a rapid method for typing meat emulsions. The test is extremely rapid and can be performed with simple equipment while the emulsion is being prepared. It is a predictive test rather than a simulation of cooking in smokehouses. Having established confidence in its reliability, we have carried out experiments comparing it with three existing methods for emulsion stability determination. The meat emulsions used ranged from stable to very unstable as determined by stability evaluations of frankfurters produced from the emulsions.

EXPERIMENTAL

Preparation of emulsions and frankfurters

Series 1. A meat emulsion was manufactured from the following ingredients: 8.2 kg lean cow meat, 2.7 kg beef heart, 5.6 kg lean pork shoulder, 8.2 kg pork fat, 6.7 kg ice, 3.8g sodium nitrite, 13.1g sodium ascorbate, 490g sucrose, 622g salt, and 130g commercial frankfurter seasoning. The cow meat, heart, pork and pork fat were ground through a 3/4 in. plate and individually bagged, frozen and stored at −31.7°C. The meat, by-products and fat were thawed at 0.5°C. All meat and by-product ingredients were ground through a 3/16 in. plate. The meats, by-product, and one-half of the ice were comminuted for 30 sec in a Koch-Alpina Pb-50 chopper set at 2500 rpm. The spice-cure mixture was added and the batch was chopped for another 30 sec. Then the remaining ice and the pork fat were added, and the mixture was comminuted, with 2 kg lots being withdrawn when temperatures of the mixture reached 15.6°C. 21.1°C, 23.9°C and, finally, 26.7°C. Portions of the lots were removed for stability tests and the remainder of the lots were stuffed into #29 No-Jax casings (Union Carbide), linked into 15 cm lengths and cooked and smoked to 71.1°C. The frankfurters were cooled to an internal temperature of 32°C by showering and were stored in a 0.5°C cooler. Product comminuted to 15.6°C contained 11.0% protein, 29.8% fat and 54.1% moisture.

Series 2. A second batch of frankfurters was made with the same formula but different lots of fresh, unfrozen meat. Processing also differed from the above in that the beef was presalted and held overnight at 1° C before sausage making and the batch was comminuted, with lots withdrawn at 14.4°C, 22.0°C and, finally, 24.4°C. The finished frankfurters from the lot comminuted to 14.4°C contained 11.1% protein, 30.2% fat and 53.4% moisture.

All authors are with the USDA Eastern Regional Research Center, FR-SEA, Philadelphia, PA 19118.

Emulsion stability tests

Phase testing method. The procedure for predicting the stability of raw emulsion was as follows: 0.5g of raw sausage emulsion was placed on a glass microscope slide. Four drops of cottonseed oil (CSO) were dropped on the emulsion from a medicine dropper. The emulsion and the oil were stirred for 10 sec with a fire-polished glass rod (2 mm o.d.), the mixing effects being observed throughout the test in ordinary light with the unaided eye. Observations were scored on a 4-point scale as follows: 1 – mixing rejected; 2 – mixing resisted; 3 – mixing and swelling occurred; and 4 – mixing readily occurred. Stabilities associated with these scores are as follows: 1 – stable; 2 – marginally stable; 3 – unstable; 4 – very unstable.

The stability of the meat emulsions prepared in Series 1 were classified by a panel consisting of 1 experienced and 13 unexperienced members. Immediately prior to the panel session, the rationale of the test was explained to the inexperienced members and they were instructed in the technique and given 10 min to practice with prepared emulsions, using the examples in Figure 1 for reference. These photographs were taken with a vertical view camera with a Polaroid 545 film-back; the emulsions had been comminuted at temperatures ranging from 14–26°C during preliminary work. The scoring of the unknown samples was carried out without reference to the training aids.

In addition to phase test scoring, triangle tests were made on emulsions prepared in Series 2 by an 8-member panel making a total of 8 judgments in each test, 6 correct judgments being required to differentiate at the 5% level of confidence as indicated by Roessler et al. (1948).

Cooking-centrifugation tests

The stability of the emulsions was determined in triplicate by the cooking-centrifugation procedures described by Meyer et al. (1964) and Saffle et al. (1967) and the cooking procedure of Townsend et al. (1968).

Frankfurter cooking tests

Fat release on cooking was determined in triplicate by the consumer and severe cooking tests described by Tauber and Lloyd (1947).

Statistical methods

Standard deviations were calculated and t-tests were performed by procedures described by Snedecor and Cochran (1956).

RESULTS

TABLE 1 presents the results obtained with the phase testing method and the methods of Saffle et al. (1967), Meyer et al. (1964), and Townsend et al. (1968) in determining the stability of the emulsions in Series 1. Data are also given on the degrees of emulsion breakdown which occurred during the production (fat capping) and subsequent cooking tests on frankfurters. In general, the appearance of finished frankfurters and the results of consumer and severe cooking tests indicated that emulsion stability decreased as the temperature of comminution increased. Evidence of this effect was shown by all three emulsion stability tests as well as the phase testing method. With the phase testing method, the mean score obtained on the emulsion comminuted to 15.6°C (1.4 ± 0.8) was lower than that (1.9 ± 0.8) obtained on the emulsion comminuted to

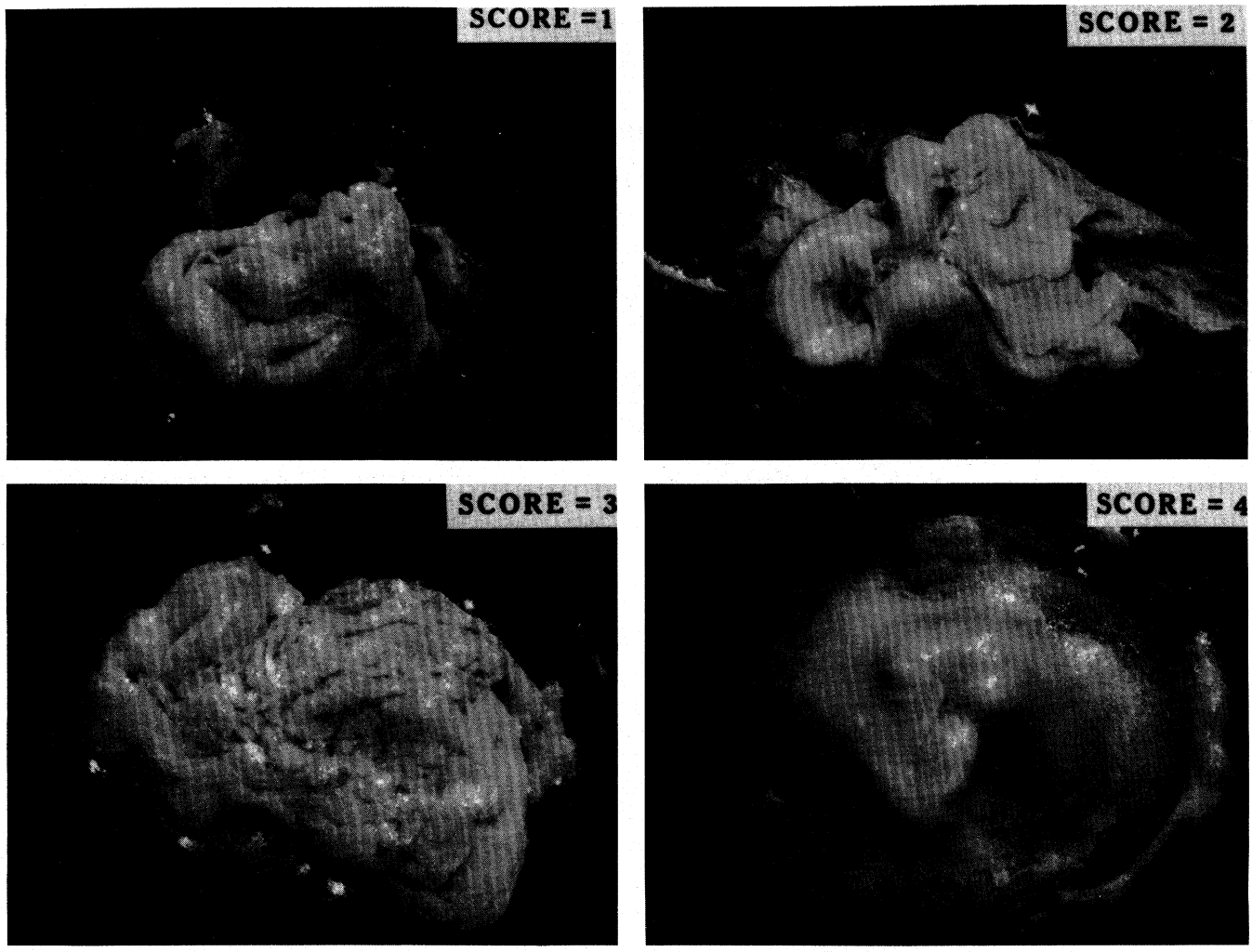

Fig. 1—Appearance (3.2X) of oil treated meat emulsions after mixing. Scores 1 to 4 based on observations as follows: 1—rejected mixing; 2—resisted mixing; 3—mixing-swelling occurred; and 4—mixing readily occurred.

21.1°C, but the difference was of a low order of statistical significance (P = 0.10). The method of Saffle et al. indicated a relative lack of stability in the emulsion comminuted to 21.1°C, with a higher degree of probability (P = 0.05). This instability was also suggested by the Meyer et al. and Townsend et al. emulsion tests and the frankfurter cooking tests of Tauber and Lloyd (1947), but the differences were not significant at the 95% level of confidence. With the phase testing method and all other methods the emulsions comminuted to 23.9 or 26.7°C were less stable than those comminuted to 15.6 or 21.1° C (P = 0.05). Only the method of Saffle et al. provided statistically sig-

Table 1—Mean values[a] obtained by methods of determining the stability of meat emulsions

Comminution temperature, 1°C	Emulsion stability tests			Phast testing score[e]	Stability evaluation in frankfurters		
	Saffle[b]	Meyer[c]	Townsend[d]		Fat capping	Consumer cook[f]	Severe cook[f]
15.6	0.5 ± 0a	0.4 ± 0.4a	0.1 ± 0a	1.4 ± 0.8a	none	0.2 ± 0.02a	0.9 ± 0.02a
21.1	1.7 ± 0.4b	1.3 ± 0.3a	0.3 ± 0.2a	1.9 ± 0.8a	few small caps	2.7 ± 1.5b	3.1 ± 1.3b
23.9	10.7 ± 1.5c	3.0 ± 0.4b	2.4 ± 1.6b	3.3 ± 0.9b	mottled with fat	11.5 ± 1.5c	12.6 ± 0.9c
26.7	13.7 ± 0.3d	4.0 ± 0.4b	3.9 ± 1.2b	3.0 ± 0.8b	large caps	14.9 ± 0.9d	16.3 ± 1.3d

[a] Mean values within a column followed by the same letter or letters do not differ significantly at the 5% level.
[b] Fat released, % by weight of emulsion
[c] ml fat per 25g emulsion
[d] ml fat per 100g emulsion X 100
[e] Mean phase testing method scores on a 4-point scale indicative of the following: 1—stability; 2—marginal stability; 3—instability; 4—marked instability.
[f] Fat released, % by weight of frankfurters

nificant differentiation (P = 0.05) between the very unstable emulsions produced on comminution to 23.9 and 26.7°C.

Table 2 shows the results of an evaluation and a comparison of the sensitivity of the Saffle and phase testing methods, with the triangle test used to evaluate the latter. Comparison of the data from the consumer cook, severe cook, and the Saffle tests, particularly with regard to emulsions comminuted to 21.1 and 22°C shown in Tables 1 and 2, respectively, indicates that emulsions prepared for Series 2 were more stable. This can be attributed to processing with unfrozen materials and presalted beef ingredients. With the results of frankfurter cooking tests for reference, both the Saffle and the phase testing methods were sensitive (P = 0.05) to the instability produced by increasing the temperature of comminution from 22.0 to 24.4°C.

DISCUSSION

THE PHASE TESTING method we have developed for determining meat emulsion stability is an application of the phase dilution method for determining emulsion types. The latter method depends on the fact that an emulsion is readily dilutable by the liquid which constitutes the continuous phase (Hauser and Lynn, 1940). Microphotographs of meat emulsions show that they are dispersions of fat droplets in an aqueous medium (Hansen 1960; Ackerman et al., 1971) which, in addition to water, contain soluble proteins and other soluble muscle constituents and segments of muscle fibers and connective tissue fibers (Forrest et al., 1975). Our tests of the effects of mixing water with meat emulsions showed that, with careful stirring, water readily dilutes stable emulsions, as would be expected with emulsions of the oil-in-water type. Dilution of unstable emulsions was not readily attained. We investigated the corollary principle that stable emulsions would not be miscible or dilutable with added oil and that degrees of miscibility or dilution would indicate relative stability. Use of the technique not only permitted differentiation between stable and unstable emulsions, but differences were more clearly distinguishable than by the technique involving dilution with water. The effectiveness of the method in the hands of a briefly trained panel demonstrated the simplicity of determining emulsion stability. This, as well as its rapidity and sensitivity to marginal instability are factors recommending the method for use in research and processing.

Table 2—Evaluation[a] of sensitivity of phase testing method

Comminution temp, °C	Emulsion stability tests: Saffle[b]	Emulsion stability tests: Phase testing in triangle tests[c,d]	Stability evaluation in: Consumer cook[b]	Stability evaluation in: Severe cook[b]
14.4	0.1a	a (1)	0.2 ± 0.1a	0.8 ± 0.1a
22.0	0.1a	a,b (1)	0.3 ± 0.0a	1.2 ± 0.3a
24.4	1.1 ± 0.06b	c (2)	3.8 ± 1.2b	7.2 ± 1.2b

[a] Mean values within a column followed by the same letter or letters do not differ significantly at the 5% level.

[b] Fat released, % by weight of emulsion, or frankfurters

[c] Total of 8 judgments, 6 correct required for 5% level of confidence

[d] Phase testing scores indicated in brackets

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